EP - 155 - 2001

1) Answer the questions below for the inductor shown in Figure 1.1 where v_L is the voltage drop across the inductor and i_L is the current through the inductor.

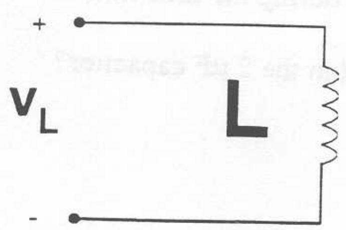


Figure 1.1

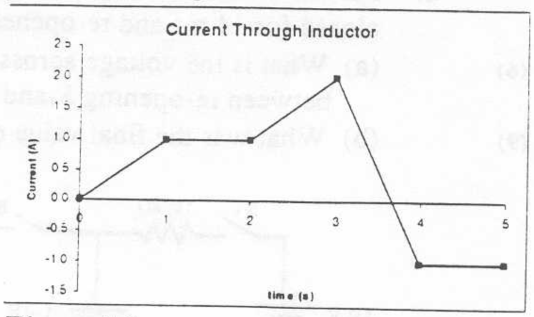


Figure 1.2

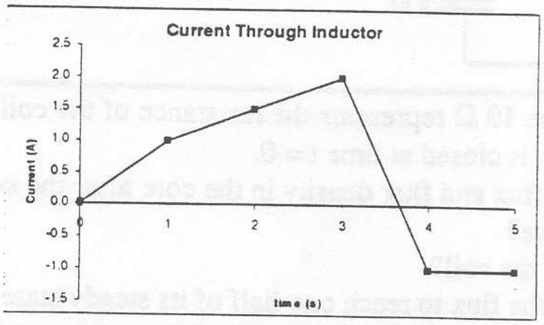


Figure 1.3

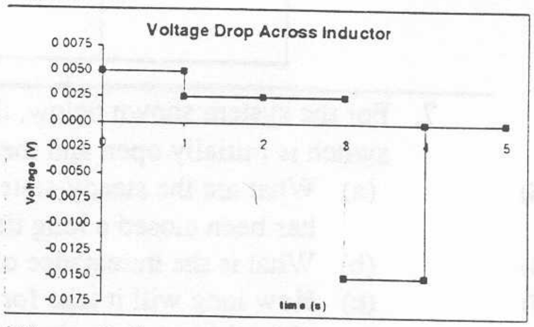
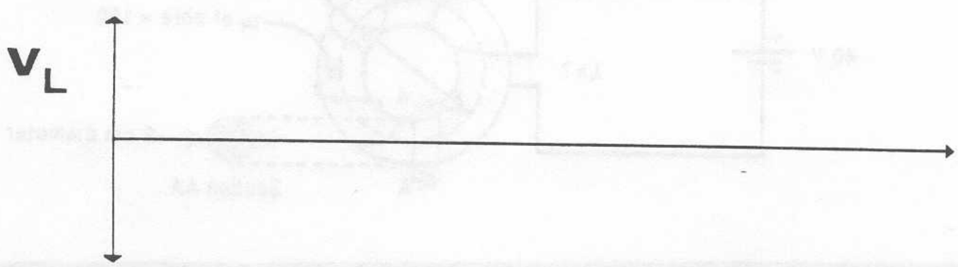
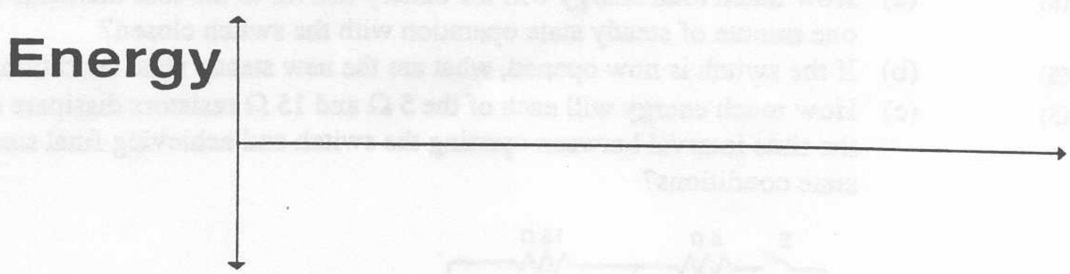


Figure 1.4

a) If the current i_L is given in Figure 1.2 and it is known that the inductor has ***1 mH*** inductance draw a plot of the voltage v_L as a function of time. ***(5 marks)***



b) If the current i_L is given in Figure 1.2 and it is known that the inductor has ***1 mH*** inductance draw a plot of the energy contained within the inductor as a function of time. ***(5 marks)***



c) If the current i_L is given in Figure 1.3 and the voltage v_L is given in Figure 1.4 then what is the new inductance L? ________________ ***(5 marks)***

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2) In Figure 2.1 the capacitor is initially uncharged. Close the switch and then wait for a long while.

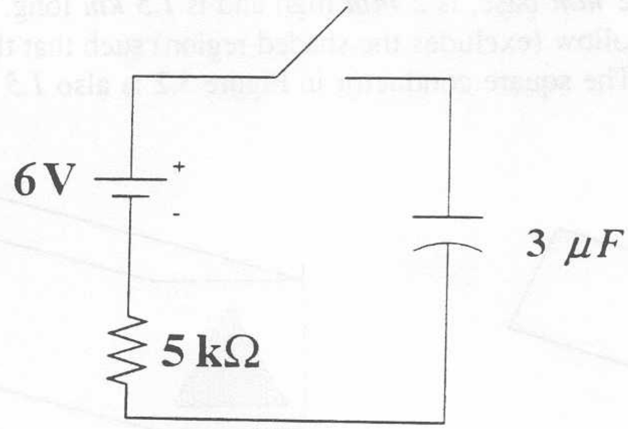

Figure 2.1

In steady state:

a) How much energy does the capacitor store? 54μJ *(2 marks)*
b) How much energy has the battery delivered to the circuit? ____________ *(3 marks)*
c) How much energy has the resistor dissipated? ____________ *(4 marks)*

The following questions do not relate to Figure 2.1 and are worth **2 *marks each***.

d) If a resistor is connected across the terminals of a *5 V* battery and *6 J* of energy are dissipated in this resistor in twenty seconds how much energy is required to move *+6 C* of charge from the negative to the positive end of the resistor?

____

e) If, in steady state, an inductor has *2 J* of energy stored in it how much energy is given off in the time *−2 C* of charge flows from one end of the inductor to the other? ____________

f) If *2 C* of charge flow through a *5 kΩ* resistor in *15 seconds* then what is the average power dissipated in this resistor during those *15 seconds*?

____

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3) Consider the two long conductors shown in Figures 3.1 and 3.2. The conductor in Figure 3.1 has a *2 mm* base, is *2 mm* high and is *1.5 km* long. The conductor shown in Figure 3.2 is hollow (excludes the shaded region) such that the other conductor fits perfectly into it. The square conductor in Figure 3.2 is also *1.5 km* long and is *3 mm* by *3 mm*.

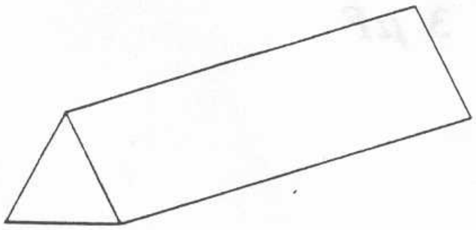

Figure 3.1

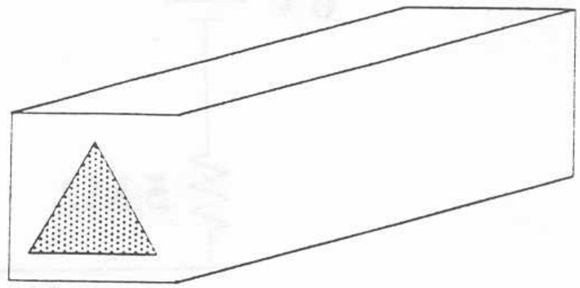

Figure 3.2

The conductor in Figure 3.1 is a metal alloy with $\rho = 3.2 \times 10^{-7}\ \Omega m$ and $\alpha = 2.1 \times 10^{-2}\ (^{\circ}C)^{-1}$ while the conductor in Figure 3.2 is a different metal alloy with $\rho = 9.2 \times 10^{-6}\ \Omega m$ and $\alpha = -1.6 \times 10^{-2}\ (^{\circ}C)^{-1}$. The coefficients are relevant to the conductors at *20 °C*.

i) What is the resistance of each component at *20 °C*?
Figure 3.1 ________________ *(2 marks)* Figure 3.2 ________________ *(2 marks)*

ii) What is the resistance of each component at 5° C?
Figure 3.1 ________________ *(2 marks)* Figure 3.2 ________________ *(2 marks)*

The component in Figure 3.1 is fitted into the hollow opening of the component in Figure 3.2 and the new configuration is left to cool to *5 °C*. The resulting composite component is then connected length wise across the terminals of a *15 V* battery.

At the new temperature of *5 °C* :
iii) How much current is drawn from the battery? ________________ *(3 marks)*
iv) What current flows through the outer conducting metal? ______________ *(2 marks)*
v) What current flows through the inner conducting metal? ________________ *(2 marks)*

4) Consider the following circuit:

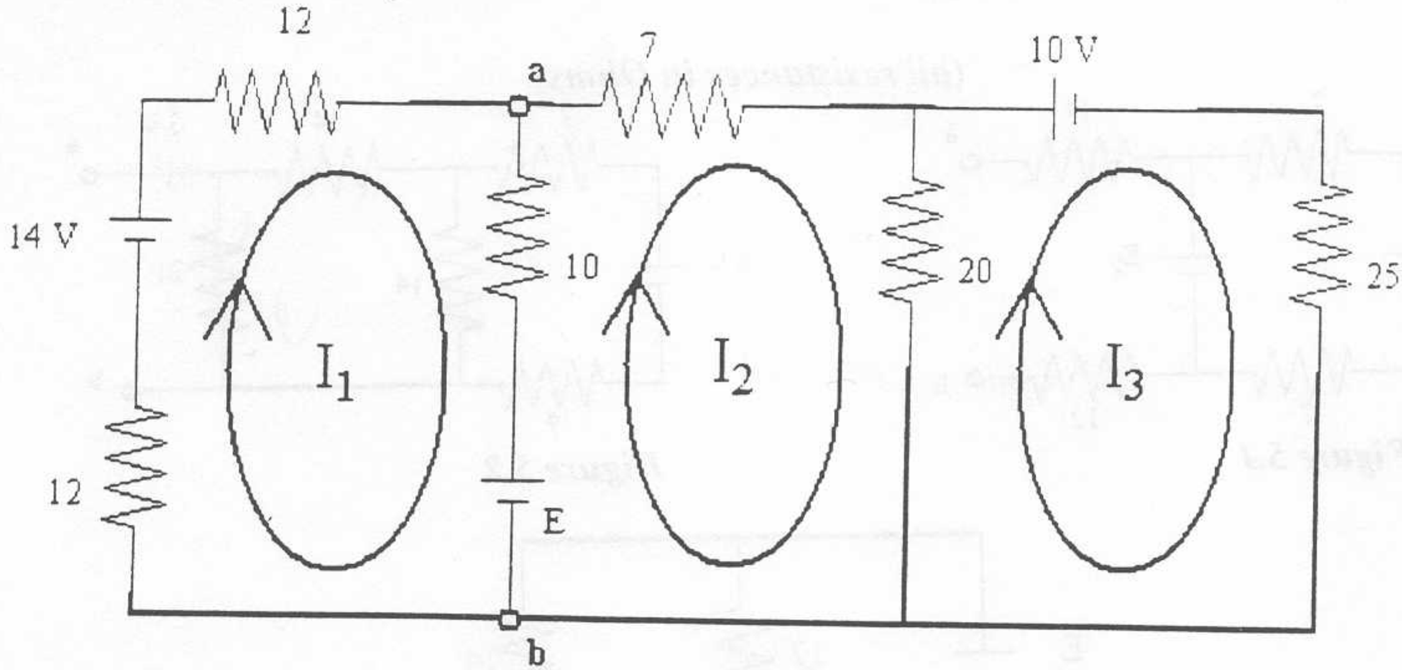

Figure 4.1
(all resistances in Ohms)

Given $I_1 = 0.323293\ A$ and $I_2 = 0.099195\ A$:

i) What is the voltage drop across the $10\ \Omega$ resistor? ________________ *(3 marks)*
ii) What is the voltage V_{ab}? ____________________ *(4 marks)*
iii) What is I_3? __________________ *(4 marks)*
iv) What is the rate of energy dissipation in the $20\ \Omega$ resistor? ____________ *(4 marks)*

5) Given the following circuit diagrams:

(all resistances in Ohms)

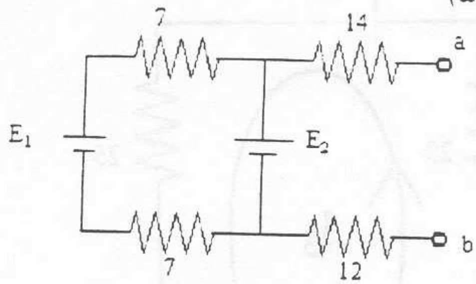

Figure 5.1

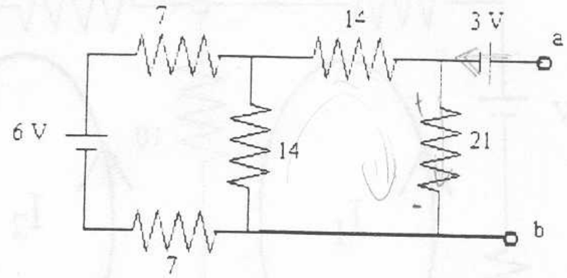

Figure 5.2

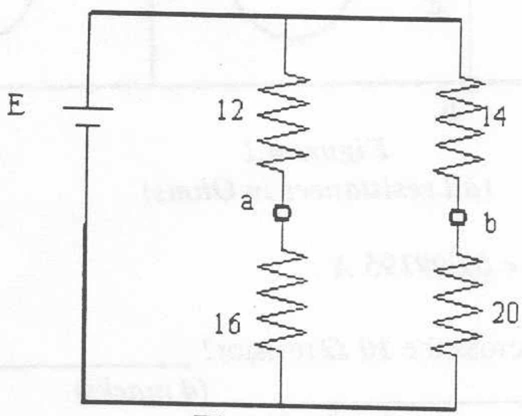

Figure 5.3

i) What is the Thevenin equivalent resistance with respect to points ***a*** and ***b*** for each of the circuits: ***(all resistances in Ohms)***

Figure 5.1) ______________ ***(2 Marks)*** Figure 5.2) ____________ ***(2 marks)***

Figure 5.3) ______________ ***(3 marks)***

ii) What is the Thevenin equivalent voltage for the circuit in Figure 5.2?

_______________ ***(5 marks)***

iii) What is the maximum amount of power that can be dissipated in a load resistor placed between ***a*** and ***b*** in the circuit in Figure 5.2? _______________ ***(3 marks)***

6) Consider the unknown components X and Y in the circuit diagram in Figure 6.1. It is known that component X is a resistor and Y is an ideal battery.

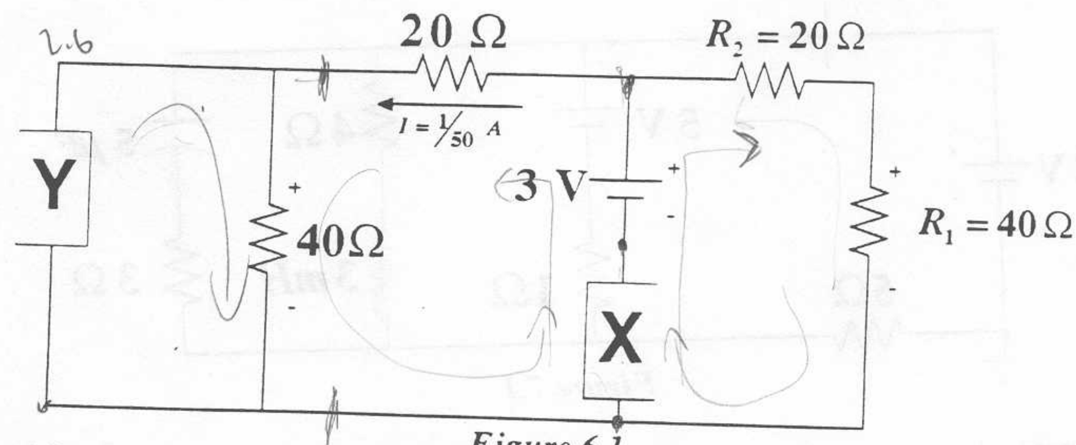

Figure 6.1

If the voltage drop (constant with respect to time) across resistor R_1 is equal to $1.6\ V$ and the polarities marked on the two resistors are correct, then what are the values of each of the unknown components. ***Hint*** : Answer last three parts first.

Component X: 15 Ω *(5 marks)*
Component Y: 3.5 V *(5 marks)*

What is the current through R_2? 40 mA *(1 mark)*
What is the current through component X? 60 mA *(1 mark)*
What is the current through component Y? 87.5 mA *(3 mark)*

7) Given the circuit diagram in Figure 7.1 :

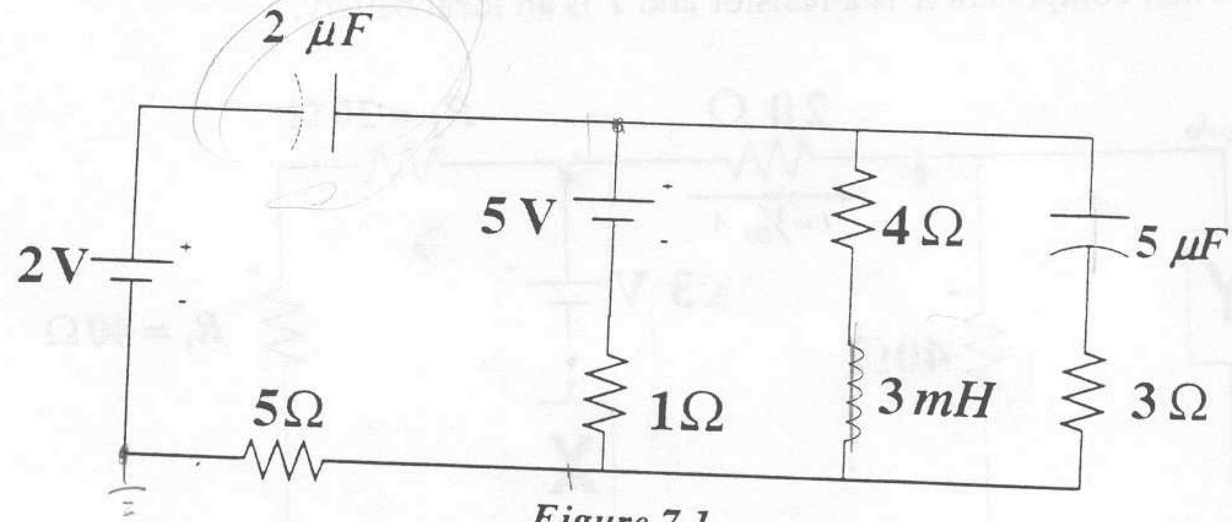

Figure 7.1

In steady state what are :

i) The current through the *4 Ω* resistor? 1A
ii) The energy stored in the inductor? 1.5mJ ____________ *(2 marks)*
iii) The current through the *1 Ω* resistor? 1A ____________ *(2 marks)*
iv) The current through the *5 Ω* resistor? 0A ____________ *(2 marks)*
v) The energy stored in the *2 μF* capacitor? ____________ *(2 marks)*
vi) The voltage drop across the inductor? ____________ *(3 marks)*
vii) The voltage drop across the *5 μF* capacitor? ____________ *(2 marks)*
(2 marks)

8) Given the circuit in Figure 8.1 where C_1 and C_2 have a charge of $Q = 0$ at time $t = 0$ s when the switch is closed.

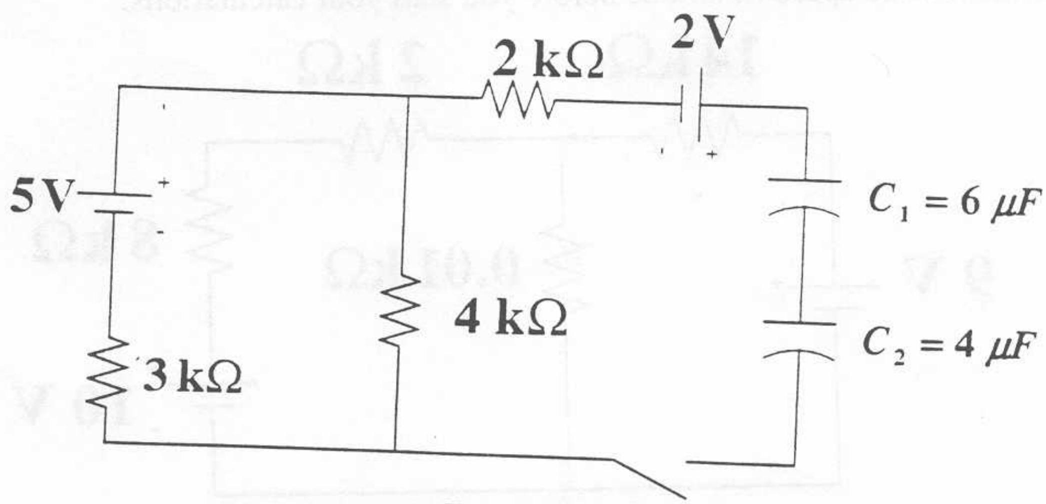

Figure 8.1

i) For the purpose of transient analysis reduce the circuit in Figure 8.1 to one battery, one resistor and one capacitor and clearly mark these values on Figure 8.2. ***(4 marks)***

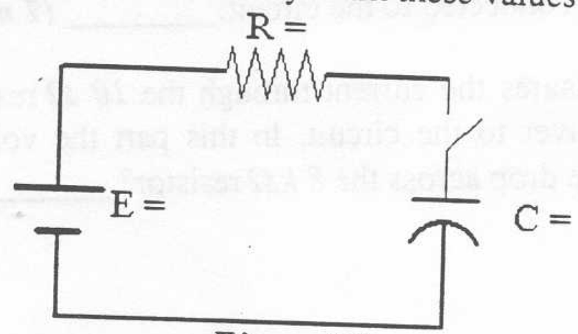

Figure 8.2

ii) At time $t = 0.5$ s, what is the voltage drop across the capacitor that is shown in Figure 8.2? ____________ ***(3 marks)***

iii) If at any time the charge on the equivalent capacitor in Figure 8.2 is 4.8×10^{-6} C, what is the charge on capacitor C_1 in Figure 8.1? ________________________ ***(4 marks)***

iv) Given the initial condition ($Q = 0$ at $t = 0$ s) and the circuit in Figure 8.1, what is the charge on capacitor C_2 at a time equal to 2τ where $\tau = RC$ (the product of the resistance and capacitance in Figure 8.2)? __________________ ***(4 marks)***

Given the circuit shown in Figure 9.1 along with a voltmeter that has internal resistance $R_V = 15\,k\Omega$ and an ammeter with internal resistance $R_A = 5\,\Omega$. Look for simplifications or approximations before you start your calculations.

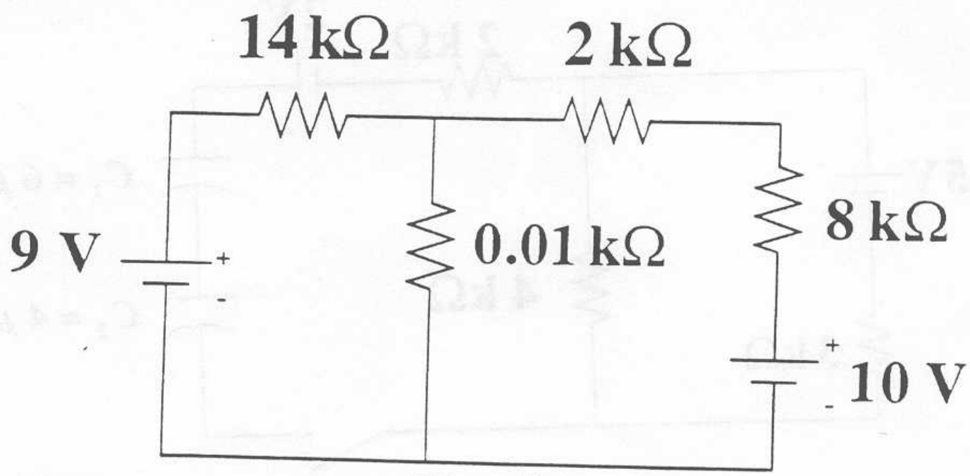

Figure 9.1

a. What is the voltage drop across the *14 kΩ* resistor, as measured by the voltmeter, if the ammeter is used to monitor the current drawn from the *10 V* battery? Note that both meters are connected to the circuit.________ *(7 marks)*

b. If the ammeter measures the current through the *10 Ω* resistor what power does the *9 V* battery deliver to the circuit. In this part the voltmeter simultaneously measures the voltage drop across the *8 kΩ* resistor? __________ *(8 marks)*

10) Answer the following questions given that C_1 and C_2 in Figure 10.1 are two parallel plate capacitors with identical dimensions and different dielectric fillers. Remember that $\varepsilon_0 = 8.85\times10^{-12}\ F/m$.

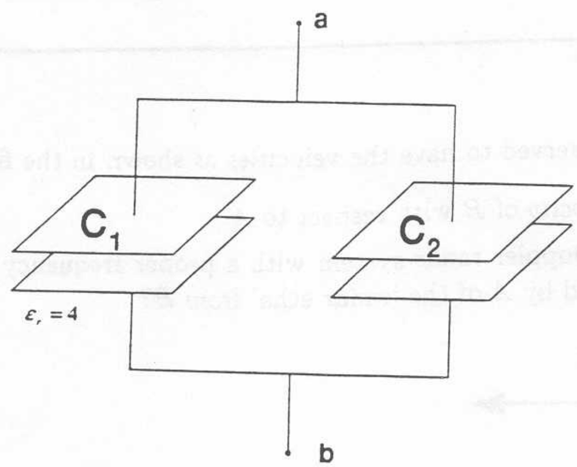

Figure 10.1

If the areas of the plates are $5\ cm^2$, the distances between the plates are $2\ mm$, the voltage difference V_{ab} is $5\ V$ and C_2 is $5\text{x}10^{-6}\ F$ then:

a) What is the capacitance of C_1? ________________ *(2 marks)*
b) What is the charge on C_1? ________________ *(2 marks)*
c) What is the relative dielectric constant of the material that fills the space in between the plates of C_2? ________________ *(3 marks)*
d) What is the charge on C_2? ________________ *(3 marks)*

Use Figure 10.2 for the next part of this question.

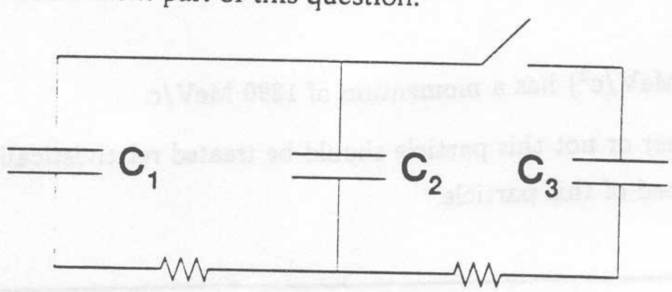

Figure 10.2

e) Given that $C_1 = 5\ \mu F$, $C_2 = 2.5\ \mu F$ and $C_3 = 4\ \mu F$ along with the information that the voltage drop across C_2 is $5\ V$ and the voltage drop across C_3 is $0\ V$ before the switch is closed what is the voltage drop across C_2 after the switch is closed and the charge is given time to settle? ________________ *(5 marks)*

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